ENEL Produzione experience in designing and commissioning DeNOx-SCR Systems

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The italian emission limit of nitrogen oxides is 200 mg/Nm^3 (@3-6% of O_2), which corresponds to 70 g/GJ, 56 g/GJ and 54 g/GJ for solid, oil and gas fuel respectively, and it is applied to new installation and to plants of power > 500 MW_{th}, although lower limits can be fixed by local authorities.

ENEL Produzione has developed a wide experience in design, start-up and operation of NOx control systems. Primary control technologies consisting in staged combustion (BOOS, OFA and reburning) and low-NOx burner utilization have been applied to coal, oil and gas fired power plants of more than 18 GWe installed. Standard DeNOx-SCR in high-dust configurations, where flue gas exiting the boiler economizer are directly treated before particulate removal, have been installed yet in 13 GWe power plants. Recently, two power plants were retrofitted with different SCR systems and the general design criteria and the result of commissioning are reported.

The DeNOx system installed at Sulcis Power Station (Sardinia Italy) treats a gas flow rate of 1240000 Nm^3/h from the 240 MWe coal-fired unit 3. The SCR system is placed after the Flue Gas Desulfurization unit (tail-end configuration) where particles and SO_2 contents are lower than 50 mg/Nm^3 and 400 mg/Nm^3 respectively.
The S. Filippo del Mela DeNOx is a side-stream high-dust SCR treating the 60% of the total gas flow rate (900000 Nm^3/h) from the 320 MWe oil-fired unit 6.

ENEL setup the general plant design by developing the following steps:

- definition of the required performances;
- 1-D simulation of the catalyst chemistry in order to design the catalytic bed (type of catalyst and volume);
- characterization of catalyst performance on pilot scale facility (100 Nm^3/h) in order to assess the DeNOx efficiency, the SO_2 to SO_3 conversion and the bed pressure drop;
- design of the SCR reactor shell and internals by 2-D and 3-D fluid dynamic simulation and chemical modeling in order to assess the overall process performance.

The performance required and the criteria used in designing the new SCR systems differ according the installation and the main fuel used. The high dust configuration reactors are designed in order to comply with the emission limit, corresponding usually to the 75-80% of NOx reduction, and to warrant the ammonia slip < 1 ppm after 1-3 year. The new installations are constituted by a reactor with 3 catalyst layers plus 1 supplementary each one equipped with soot blowers.

S. Filippo del Mela is an heavy fuel oil/orimulsion fired plant and the side stream SCR installed was design to perform the 85% of NOx reduction on the treated flue gas (60% of the total flow rate) in order to achieve the 50% of total nitrogen oxides reduction. Two catalyst layers of honeycomb type (pitch>5 mm) were installed The specifications for the inlet flue gas are 400 mg/Nm^3 NO_2 @3% O_2 and 400°C and the design out-stream conditions are 66 mg/Nm^3 NO_2 @3% O_2 and 370°C.
The main advantages of side stream SCR consist in minimizing the catalyst volume, the reactor dimension and, consequently, reducing the capital cost up to 20%. This configuration is usually

coupled with some other combustion control technology when to reduce NOx emissions by less than 60% is required. By treating part of the flue gas, lower conversion of SO_2 to SO_3 occurs (<0.8%), reducing plugging and corrosion problems in cold-end of the plant. In addition, the bypass allows to optimize the process performance by maintaining a constant gas flow rate to the reactor even during boiler low load operations.

For the Sulcis power plant unit #3, a coal fired unit equipped with ESP and FGD, the tail-end SCR design was applied. The required performances were a NOx removal of about 80%, ammonia slip < 1 ppm and SO_2 to SO_3 conversion < 0.8%. The system consists of one reactor treating 100% of flue gas by means of two plus one supplementary layers (honeycomb of pitch > 4) where no soot blowing are installed because the treated gas are sufficiently clean. The injection grid consists of 40 valve manifolds of 6 nozzles each settled at an angle of 30° with the plane orthogonal to the main flow direction.

After the plant installation ENEL followed the commissioning of the SCR and developed a procedure in order to optimize the ammonia injection grid by experimental measurements upstream and downstream the catalyst and application of a mass-balance model. This procedure starts with the air distribution measurements up-stream the reactor layers in cold conditions. The gas velocity, NOx and O_2 concentration distribution were measured upstream the ammonia injection and down-stream the reactor by a grid of respectively 40 and 48 sampling points. The ammonia injection was optimized point by point by means of an algorithm based on the flue gas composition measurements coupled with a 3D simulation of reactor.
For the three case applications the SCR performances obtained were:

- NOx reduction of about 80%,
- ammonia slip< 0.5 ppm
- SO_2 to SO_3 conversion < 0.5 % within the design requirements.